RADIUM

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VOL. XVIII OCTOBER, 1921 No. 1

CONTENTS

REVIEWS AND ABSTRACTS

A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES

RADIUM

A MONTHLY JOURNAL DEVOTED TO THE CHEMISTRY, PHYSICS AND THERAPEUTICS OF RADIUM AND RADIO-ACTIVE SUBSTANCES

Edited by Charles H. Viol, Ph. D., and William H. Cameron, M. D with the assistance of collaborators working in the fields of Radiochemistry, Radioactivity and Radiumtherapy.

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MEASURMENT OF ABSORPTION AND DOSAGE OF GAMMA AND X-RAYS BY IONOMETRIC METHODS – A REVIEW OF RECENT WORK

The general adoption of the gamma ray method of standardizing radium preparations, and the setting up of the International Radium Standard constitute very important steps in the advance which radium therapy has made in the last decade, making it possible for radium workers to handle definitely known amounts of radium and to describe radium treatment in terms of a common unit of quantity—the milligram of radium element,* or its equivalent, the millicurie of radium emanation.

In the field of roentgenology, the development of the Coolidge tube undoubtedly has marked the greatest advance, making possible as it does, the standardizing of x-ray output, and simplifying technic, particularly where large doses of the x-ray are used, as in therapy. In the case of radium there is a definite output of beta and gamma ray energy per unit of mass of radium, while in the case of the x-ray tube, both the quantity and quality of rays may be varied widely, and with the older forms of gas tubes, these variations were not definitely controlled. However, the advent of the Coolidge tube has brought this desirable control.

*Some still adhere to the earlier used unit, the milligram of pure crystalline radium bromide, $RaBr^2\ 2H^2O$. The radium element content of this salt is 53.6%, and so data given in terms of this unit is approximately and readily transformed to the radium element basis by dividing the given figure by two. The data from the London Radium Institute are always given in the bromide unit. The earlier French activity units were based on the assumption that the total ionizing activity of pure crystalline radium bromide was 2,000,000 times that of pure uranium. Thus, on this basis, 50% pure radium bromide was said to be of 1,000 000 activity, etc. The gamma ray method of standardizing radium has entirely displaced the activity unit.

The measurements of gamma ray intensities have always been carried out by use of the electrometers (electroscopes) making use of the ionization which these rays produce in air and other gases. It was possible to estimate the absorption of these rays in matter, and absorption coefficients were determined for the gamma rays of different penetrating powers, in various substances by measuring the residual amount of radiation after the beam had passed through known thicknesses of the substances.

In the case of x-rays, the dosimetric methods employed by the roentgenologists have in the main been photochemical, in that the intensity of the rays was determined by observing their action in such reactions as the darkening of a photographic plate (Kienbock strips, effect on silver salts) barium platino cyanide crystals (Sabouraud-Noire pastille) and selenium (Fuerstenau intensimeter).

As long as the unscreened x-rays were used these more or less inadequate methods were comparatively useful, and certainly far better than nothing. The use of filtered x-rays in massive dose treatment soon showed that the indications of these photochemical reactions were entirely different for the filtered rays and the unfiltered, and varied according to the quality of the rays used.

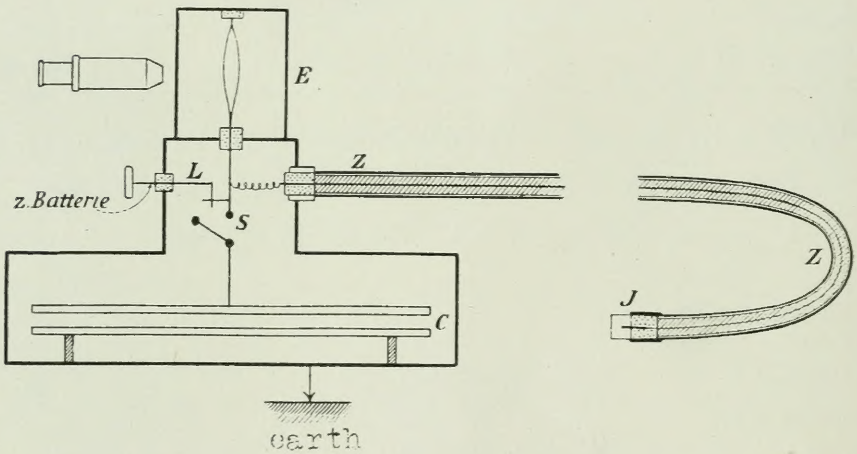


Figure 1. Schematic diagram of apparatus used by Friedrich and Kroenig. E is the bifilar Wulf electrometer, the fall in potential of the threads being observed through a reading microscope. This electrometer is equipped with a charging device L connected to the battery, and an additional capacity C, which can be connected with the thread system through S. The electrode in the tiny ionization chamber J, (graphite coated horn), is connected to the electrometer by the metal sheathed rubber cable Z.

The most comprehensive comparative study of x-ray dosimetric methods is that given in Friedrich and Kroenig's book, Physikalische and Biolologische Grundlagen der Strahlentherapie* (Berlin, 1918), which Dr. Henry Schmitz has translated into English.**

*See brief review of this book by Iser Solomon translated from French in Jour. de Radiol. et Electrol. IV, 358-364, 1920, in the December 1920 issue of Radium. Important data from this book are also given in the paper by Dr. H. Schmitz, on the Newer Methods of Measuring and Applying the Roentgen Dose, in the January 1921 issue of the Journal of Radiology.

**Dr. Schmitz advises that Rebman and Company of New York will shortly issue this book. A supplemental chapter will give interesting data obtained by Dr. Schmitz during the past summer, working in Friedrich's laboratory, giving isodose measurements on the smaller sized American radium preparations.

Their observations of the action of unfiltered and variously filtered x-rays on the commonly used x-ray dosimeters brought out clearly that the same amount of x-ray energy in the form of penetrating filtered x-rays did not produce the same effect on the dosimeter as the softer unfiltered x-rays. Their work did show that the ionization in air was practically proportional to the intensity of the x-rays, irrespective of their hardness, and this led to their choice of the ionometric method for determining x-ray absorption and dosage. Since the absorption of gamma rays and x-rays is largely an electronic rather than an atomic or molecular function of matter, and since the absorbing power of atoms of substantially the same atomic weight (i. e. same electronic structure) is about equal, it is not surprising that Friedrich and Kroenig found that water has practically the same absorbing power as an equal thicknesses of muscle tissue.

By use of a small ionization chamber of graphited horn,* 0.8 mm. thick, the chamber having a volume of 1 ccm. and being connected by a long flexible cable to an electrometer, they were able to measure the actual ionizing intensity of radiation, which penetrated through the skin surface to hollow organs of the body into which the tiny ionization chamber was inserted.

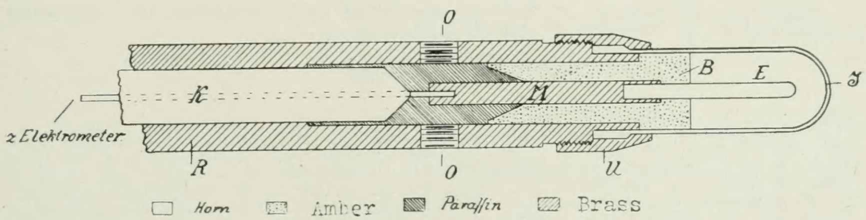


Figure 2. Section through the graphited horn ionization chamber of Kroenig and Friedrich's apparatus, showing the construction and manner of connecting the insulated graphite rod E with the charged filar system of the Wulf Electrometer, by the brass part M and the insulated copper wire K. The diameter of the ionization chamber was 10 mm. and its length, 20 mm. The graphite electrode was 2 mm. in diameter and 15 mm. long.

To study the intensity of the ionizing rays at various depths in tissue, the authors used a large vessel full of water as a "phantom," immersing the small ionization chamber to various depths below the water surface. Such measurements using x-rays filtered through 10 mm. of aluminum brought out the rather astonishing fact that the scattered x-rays acting on a point at 10 cm. below the water surface greatly increased the intensity of ionizing rays, the measured dose being 31 per cent of the water surface dose, whereas at this depth, if only the absorption and dispersion of the rays are taken into account, the calculated 10 cm. depth dose is 8.4 per cent. of the surface dose. The authors found that the magnitude of this effect of the scattered x-rays and secondary rays was mainly influenced by the size of the portal of entry, the effect being greater for the larger portals.

Friedrich and Glasser (Strahlentherapie XI, p. 20, 1920) have indicated the same general phenomenon for the gamma rays in that the actually measured dose at 10 cm. below the skin surface is 130 per

*It is very important that the walls of the ionization chamber be constructed of material having an average low atomic weight, approximating as far as possible the composition of tissue. Kroenig and Friedrich first employed aluminum (at. wt. 27) but found that the graphited horn gave better results. In most of the older work this important point has been neglected, and therefore the older data are not directly comparable with Friedrich and Kroenig's.

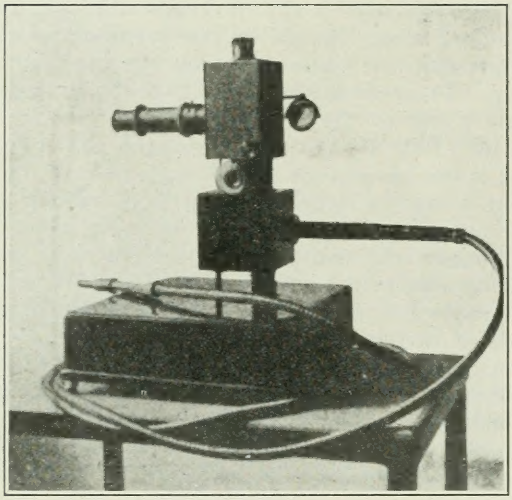


Figure 3. Photograph of Kroenig and Friedrich's apparatus for measuring gamma and x-ray intensity at a point.

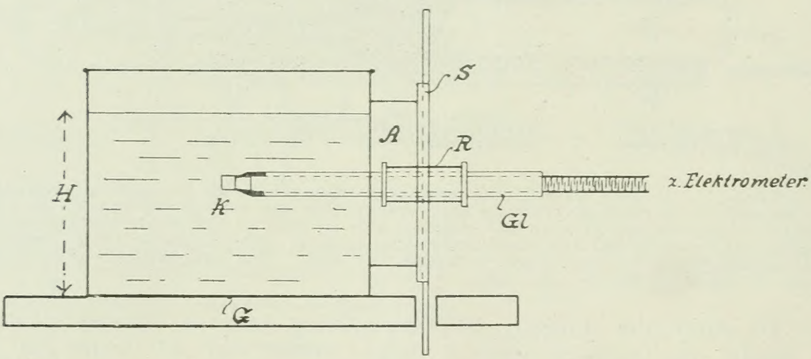


Figure 4. Schematic diagram of the water "phantom" used by Kroenig and Friedrich, to measure the intensity of ionization at various depths in water, this corresponding closely to the intensity of ionization produced in body tissues at corresponding depths. The gamma or x-ray beam played down vertically on the surface of the water contained in the cylindrical zinc vessel, 35 cm. in diameter and 25 cm. high. Water filled the vessel to a depth of 20 cm. K is micro-ionization chamber with connecting cable to the electrometer.

cent. greater than the dose based on calculations which only take into account the absorption of the rays and their divergence. R. M. Sievert, in an article on the Distribution of Intensity of the Primary Gamma Rays from Radium Applicators Used in Therapy, (Acta Radiologica (Stockholm) Vol. I, pp. 89-119, July 25, 1921), making the same general sort of measurement, with the exception that the tiny aluminum ionization chamber was placed in the axis of a glass test tube of about 1 mm. wall thickness, the test tube being immersed in water, found that the measured gamma ray dose corresponded within less than 2 per cent. with the calculated dose, calculations taking into account only absorption and divergence with distance from the source. At the same depth in water (1.5 cm.) the figures given by Friedrich and Glasser indicate a difference of over 20 per cent. between the measured and calculated

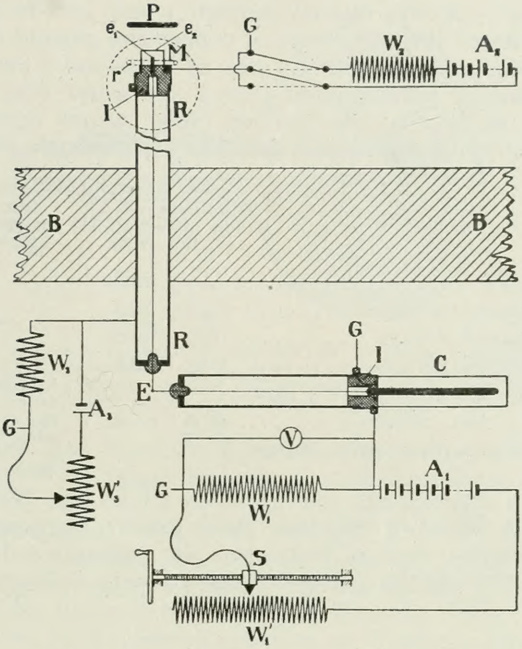


Figure 5. Schematic diagrom showing the apparatus used by Sievert to measure gamma ray ionization at a point. M is the micro-ionization chamber, with wall of thin aluminum the chamber being 9 mm. in diameter and 7 mm. long. E is the tiny brass electrode which connects through an insulated wire with the "Balkenelectrometer" E to which is connected the condenser C. A 5 cm. thick lead plate BB screened the electrometer and condenser from direct action of the gamma rays. The discharging effect of the gamma rays acting on the micro-ionization chamber was compensated by increasing the charge on the condenser C by means of the battery A^1 and resistance W^1 and W^11, the precision voltmeter V showing the difference of potential between the condenser and earth. The measure of ray intensity was the time required for the change of potential of the condenser from one constant value to another, the electrometer reading being held meanwhile at the null or zero point. The distance between the radium preparation and the electrometer was 50 cm. and over the electrometer was a 3.5 cm. lead housing.

doses. Part of the difference between his results and Friedrich and Glasser's, Sievert accounts for by their use of a different gamma ray absorption factor, the use of Sievert's figure, in the calculated value for gamma ray intensity at 10 cm. below the water surface, giving a figure only 70 per cent. different from the value measured by Friedrich and Glasser, whereas their calculated value differed by 130 per cent. from the measured value. The only other notable difference lay in the use of a glass tube by Sievert, and this would account for his getting lower value for the gamma ray intensity, since the glass would screen out soft secondary rays of the beta ray type. Sievert's method therefore would more accurately measure gamma ray intensity, while Friedrich and Glasser's method would more nearly determine the total ionizing energy.

Interesting figures given by Friedrich and Kroenig in their book are those which they found for the absorption of unscreened and of variously filtered x-rays and gamma rays in water and aluminum. They used a Coolidge tube, with a transformer and gas interrupter, with a parallel spark gap between plate and point of 30 cm. for the unfiltered and 3 mm. filtered x-rays, and spark gaps of 35 and 40 cm. respectively for the 10 mm. Al and 1 mm. of Cu filtered x-rays.

Measurements were made using the small ionization chamber on the absorption in water up to 10 cm. and in aluminum up to 10 mm. of the

unfiltered x-rays. X-rays filtered through 3 mm. and 10 mm. of aluminum, x-rays filtered through 1 mm. of copper and gamma rays of radium and mesothorium screened with 1.5 mm. of brass and 5 mm. of celluloid.

The thicknesses of aluminum (mm.) and water (cm.) respectively which absorb the first 50 per cent. of these various types of rays are given in the following table from the data of Friedrich and Kroenig:

	Thickness of Al, which absorbs 50% of the rays	Thickness of water (approx. same for muscle tissue) which absorbs 50% of rays
Unfiltered x-rays	2.15 mm.	1.8 cm.
3 mm. Al. filtered x-rays	4.25 mm.	2.4 cm.
10 mm. Al. filtered x-rays	6.9 mm.	3.25 cm.
1 mm. Cu. filtered x-rays	10.5 mm.	3.7 cm.
Gamma rays of Ra. through 1.5 mm. brass and 5 mm. celluloid	48.0 mm.	3.5 cm. water absorb 16.5% of the gamma rays, and 5 cm. absorb 22% from which a half absorption value of about 13.5 cm. may be calc.
Gamma rays of mesothorium screened as for Ra.	52. mm.	

From these data it is clear how much greater the penetrating power of the hard gamma rays is than even the portion of hardest x-rays available after filtering the x-rays through 10 mm. of aluminum or 1 mm. of copper.

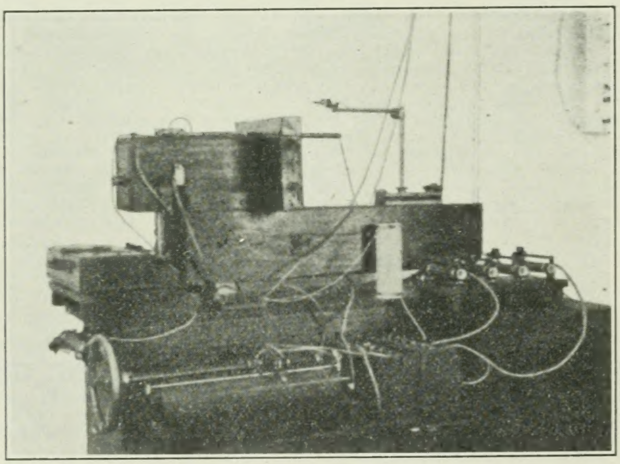


Figure 6. Photographic view of Sievert's apparatus, showing the lead-covered electrometer and condenser at upper left side, lead plate in center and insulated shaft leading from lead plate at right to micro-ionization chamber at end of shaft.

In Sievert's paper cited above, he developes complex mathematical formulae which permit the calculation of the intensity of the primary gamma rays about radium preparations, such as are used in therapy, such for example as for tubes, singly and in groups, and for plaques. The data obtained by use of these formulae were checked by experimental measurements and these results agreed closely with the computed values.

Sievert calls attention to the fact that the gamma rays of radium are not homogeneous and cites Kohlrausch's work which indicates three

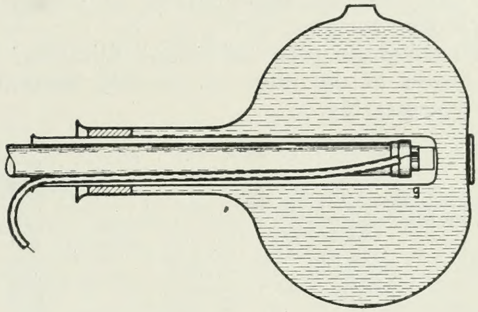


Figure 7. Arrangement used by Sievert to measure intensity of rays in water. A thin walled glass test tube G passing through the stopper of the flask, permits insertion of the shaft bearing the micro_ionization chamber, the gamma rays playing on this through what would ordinarily be the bottom of the flask.

groups of gamma rays from Ra B and C, the hardest group having a relative intensity of 8, the next softer, 6, and the softest, 1. In other words the hardest rays make up 8/15, the intermediate 6/15, and the soft 1/15 of the gamma rays from radium. Each of these types of gamma ray will be absorbed in a different measure in various materials. This point is also brought out clearly by the figures given in Failla's (Radium Research Laboratory, Memorial Hospital, New York) paper on the Absorption of Radium Radiations in Tissues—Am. Journal of Roentgenology, VIII, p15-232, May 1921. We quote the summary given by Failla of his work.

"1. The apparatus used, consisting of a gold leaf electroscope and conical ionization chamber, and the experimental procedures are described in detail.

"2. The most important limitations imposed by the experimental method adopted are discussed. They are due to:

(a) Use of a metal ionization chamber.

(b) Use of a gas as the absorbing medium in the ionization chamber.

(c) Exclusion of scattered and secondary radiation produced in tissue.

(d) Inability to reproduce in the physical laboratory physiological conditions.

"3. The absorption curves for aluminum, brass, and lead are given. From these we see that:

(a) As the filter increases the transition from soft to hard radiation is quite sharp.

(b) Beyond a thickness of filter of a few millimeters in the case of aluminum and brass the absorption is exponential ($I = I^o e^{-ud}$). In the case of lead it is not exponential in the range of thickness used.

(c) This shows that the filtration by a small thickness of metal is sufficient to give a radiation which is absorbed exponentially by metals of medium or low atomic weight. The radiation, however, is not strictly homogeneous, as indicated by the lead absorption curve.

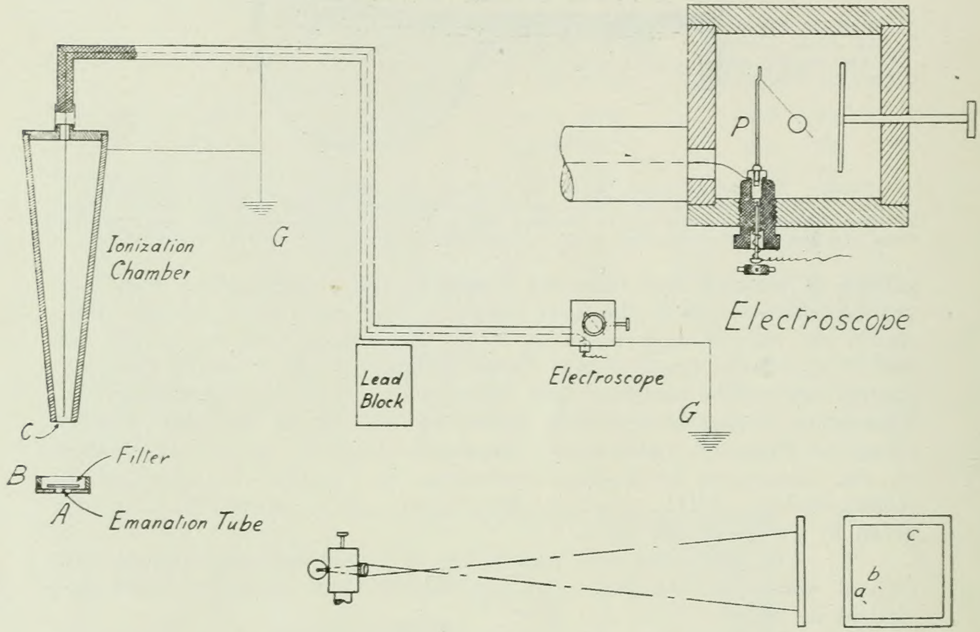
"4. The criterion for the quality of radiation to be used in deep therapy being the expoential absorption of the radiation by tissue, from Figures 3 and 4 we see that:

(a) A metal should be used as the primary filter.

(b) A secondary filter, composed of light elements like tissue, should be used to remove the soft, secondary radiation of the metal.

(c) There are different combinations of primary and secondary filters suitable for deep therapy.

(d) Beyond a certain point additional filtration, while increasing the penetrating power of the radiation slightly, decreases the intensity of the radiation considerably.



The apparatus used by Dr. Failla is shown in Figure 8. The following is quoted from his paper. "The conical ionization chamber is made of lead and is supported vertically on a suitable frame not shown in the diagram. It is 51 cm. long, 3 cm. in diameter at the smaller end, and 12 cm. at the larger end. The wall thickness is 0.8 cm. A thin steel rod, tapered to a point, is suspended along the axis of the chamber and is carefully insulated therefrom. The rod is electrically connected to the leaf post P of the electroscope by means of a fine copper wire which runs through brass tubes filled with paraffin. The electroscope is made of lead 1 cm. thick. The inside dimensions are 2.7 by 6 by 7 cm. It is arranged (as shown in the lower part of the figure) so that the gold leaf is projected on a ground glass screen. The lead cone, brass tubes and electroscope case are all connected to the ground at G. The gold leaf of the electroscope is charged by pulling a string attached to a bell crank, so that the rod B, which is connected to a suitable source of potential, touches the leaf post. The wire in the ionization chamber will then be at the same point A on the screen. In taking readings the observer sits in front of the ground glass screen, and, with a stop watch, measures the time it takes the image of the leaf to travel between the points b and c on the screen.

"The supports for the source of radiation, filter and tissue are made of hard rubber and very thin mica, as shown at AB. They are placed at such a distance from C that the source of radiation is practically at the apex of the cone. In this manner the beam of rays which enters the cone fills the whole chamber. The metallic filters are placed just above the radioactive source; the tissue is placed on the mica window B which is 1.5 cm. above the support for the filters. With this arrangement it is possible to change the filter without disturbing the tissue in any way. The lower end of the ionization chamber is closed by a very thin sheet of mica.

"The radiation we wish to measure is only the beam which enters the ionization chamber. It is necessary, therefore to shield the electroscope itself from the radiation which the source emits in all directions. For this purpose a thick block of lead is interposed between the source and the electroscope, and the latter is so constructed that no stray radiation can enter it. The brass tubes are filled with paraffin for the same purpose of limiting the effect of the radiation to the air in the ionization chamber proper. The instrument was tested to see whether the shielding was sufficient, and it was found that the effect on the electroscope which was not due to the ionization chamber was negligible. Ac-

count had to be taken, however, of the 'natural leak' of the instrument, that is, of the slow discharge of the electroscope leaf when the source of radiation which we wished to investigate was not present. This correction is made by subtracting the rate of fall of the leaf due to the natural leak alone from the rate of fall due to the combined effect of the radiation which enters the ionization chamber, and the natural leak.

"It is important to bear in mind just what we are measuring with an apparatus of this sort, because on that depend the conclusions which we may draw from the experimental results. The cone of rays which enters the ionization chamber ionizes the air in it. The formation of ions implies that energy is being used up in the process, since work must be done to separate negative from positive electricity on account of the force of attraction betwee nthe two. This energy is supplied by the radiation. The difference of potential between the wire and the walls of the ionization chamber is sufficient to cause the positive and negative ions to be separated from each other as soon as they are formed, thus preventing their recombination. Under these conditions the electric current thus produced is proportional to the number of ions produced per second, which is a measure of the energy absorbed by the air in the chamber. The electroscope, used in conjunction with a stopwatch, measures this ionization current. Consequently the readings which we obtain in this manner are proportional to the energy absorbed.'

"5. In deep therapy the limiting factor is the effect on the skin. Therefore it is important to know what fraction of the skin radiation reaches a given depth of tissue. The value of this fraction can be varied within limits by varying the distance of the applicator from the skin, or the filtration.

(a) An example is worked out to show that in the case of gamma rays it is more economical to increase the percentage of the skin radiation which reaches a deep tumor by increasing the distance of the applicator than by increasing the filtration.

(b) A second example shows that, using two sources of radiation of distinctly different penetrating power, we can get the same percentage of a skin dose at a certain depth of tissue in either case by choosing the distance of application properly.

(c) Table I shows that when the distance of the applicator is large in comparison to the tumor depth, the penetrating power of the radiation has the greater influence on the tumor dose. (This is the case of x-rays). On the other hand, when the distance of application is about the same as the tumor depth, and the radiation is very penetrating, the distance has the greater influence on the tumor dose. (This is the case of radium therapy).

(d) The table shows also that when the distances are adjusted so as to get the same skin dose and the same dose at a depth of three centimeters, using radiation of different degrees of hardness, the doses are not the same at any other tissue depth, and especially at greater depths than the one for which the doses are the same.

"6. The coefficient of absorption is the important factor which identifies radiation. The numerical value depends on the quality of the radiation and on the nature of the absorber. From Table II we see that:

(a) When the same tissue is used as an absorber and the filtration of radium rays is varied in steps from 0.48 mm. of brass to 3 mm. of lead, the coefficient of absorption gradually decreases from 0.0765 to 0.0709. But while the penetrating power of the radiation is increased 7.3 per cent. by the additional filtration, the available radiation is decreased 65 per cent.

(b) The same radiation (1.92 mm. brass filter) is absorbed to a different extent by different tissues. For soft tissues the coefficient of absorption is proportional to the density of the tissue.

(c) The absorption by tissue from different organs (except lung tissue, fat and solid bone) is nearly the same. Therefore if we take 0.075 for the value of the coefficient of absorption of gamma radiation filtered through 1.92 mm. of brass, we are sure to be on the safe side in any calculation we may make for practical use. Corresponding to this value of the absorption coefficient, the thickness of tissue necessary to absorb one-half of the radiation is 9¼ centimeters. As a round figure, easy to remember, we may take the half value thickness of human muscle tissue for gamma rays to be ten centimeters.

(d) The presence of bone in the path of the radiation is of no great consequence in regard to the amount of gamma radiation which reaches the tumor beyond it. The only part of the bone which absorbs considerably more than muscle is the solid part. But in any practical case this makes up a small fraction of the total thickness traversed by the radiation. In the case of x-rays bone plays a more important part.

"7. The results obtained from the experiments described in this paper can be used for the solution of problems in radium therapy, subject to the following limitations:

(a) The calculated amount of radiation reaching any given tissue depth is always the minimum amount which will reach this depth under the conditions of application.

(b) Skin doses of beta and gamma radiation are not to be compared according to the ionization values given in Figures 3 and 4. They must be determined independently by physiological experiments."

A paper by Edith H. Quimby (Radium Research Laboratory, Memorial Hospital, New York), on the Effect of Different Filters on Radium Radiations (Am. Jour. Roent. VII, 492-501, Oct. 1920), gives experimental results of the ionometric measurement of the absorption of radium rays (beta and gamma) by metals, and also showing the intensity of ionization by rays filtered through metal plus tissue. Mrs. Quimby used the same apparatus in her work that Dr. Failla used. Mrs. Quimby's conclusions are quoted:

"Equivalent filters of different metals have been determined, which give the same intensity of ionization in the apparatus described.

"When the radiation filtered through these 'equivalent' thicknesses is transmitted through tissue, the ionization produced is not the same.

"For thin filters, up to half a millimeter of brass or its equivalent, the radiation transmitted by lead is more penetrating than that transmitted by brass, which in turn is more penetrating than that from aluminum. When the absorption by the tissue becomes great in comparison to that by the filter, this effect is obscured.

"For thick filters, equivalent to one millimeter of brass or more this effect is reversed, the radiation transmitted by lead having a larger percentage of soft radiation than that transmitted by brass or aluminum.

"To obtain the necessary penetrating radiation for deep therapy, in general a combination of filters is necessary. When substances of high atomic weight are used as filters, a considerable part of the emergent radiation is easily absorbed in tissue. Hence the necessity of a secondary filter of low atomic weight to remove this soft radiation. The analysis by tissue of the transmitted radiation enables us to determine what additional filtration is necessary when any metal is used as the primary filter.

"For practical reasons brass is a good substance to use as a primary filter. Its secondary radiation is not very intense and can be removed

to a sufficient extent by a few millimeters of rubber, which have the same effect as an equal thickness of tissue. A thickness of 2 millimeters of brass is sufficient for deep therapy.

"The results obtained in these experiments are directly applicable to the treatment of patients, since the absorption by the tissue used is the same, within the limits of experimental error, as that by living tissue."

This paper also contains an interesting paragraph on a much mooted question of what is the best metal filter for radium :

'The best filter for deep therapy is one that will give a penetrating beam with as little secondary radiation as possible. Brass gives less secondary radiation than lead, therefore in this respect it is a better filter. Brass is also one of the easiest metals to machine; it does not rust; it is hard, so that the applicators keep their shape; it is inexpensive and easily procured. Furthermore, 2 millimeters of brass is a sufficient thickness to remove the soft radiation. Since the curves for 1.96 and 3.04 millimeters of brass are practically parallel, the extra millimeter of brass has not increased the relative penetration appreciably, but it has absorbed 4 per cent. more of the original penetrating radiation, thus decreasing the efficiency. This argument applies more strongly when 2 millimeters of lead are used as a filter, for in this case about 10 per cent. of the penetrating radiation is absorbed."

For practical reasons it is desirable to have glass radium capsules enclosed in a protective metal screen, however, it is also frequently desirable to assemble a number of radium tubes in a single metal screen. It is to avoid the handling of the bare glass tubes that has led to the supplying of a silver protective capsule, (wall thickness of 0.5 mm. and with a screening power approximately equal to 1 mm. of brass) with a brass screen (1.0 mm . wall thickness) to cover the silver tube. This combination gives practically the same result then as is obtained by the use of 2 mm. of brass, and where several silver tubes are enclosed in a single brass screen, there is no extra waste of gamma rays.

Kroenig and Friedrich show in their book that if the same amount of x-ray energy is absorbed in the same amount of tissue, dosage being measured with the graphite coated horn ionization chamber, the physiological reaction is the same, no matter what the quality of the radiation, i. e. the same reaction for equal energy quanta of radiation absorbed whether it be unscreened or screened x-rays or gamma rays.

With this important point settled, it then becomes possible to measure gamma ray and x-ray dosage in the same units, if the absorption coefficients of the rays in the tissues are known, and this can be determined by the measurement of the ray intensity at two points, first before the beam enters a tissue, and second as it leaves. This makes possible then the long desired interrelation of gamma ray and x-ray dosages. It must be strongly emphasized that the ionometric measurements are not so simple to make, and really are only to be relied on where performed by a competent operator, and Kroenig and Friedrich's work shows how important it is that the ionibation chamber be made of some low atomic weight material, since their results using an aluminum ionization chamber show very wide deviations from the results obtained with the graphite coated horn chamber.

Summarizing, we may say that the recent work on the ionometric measurement of gamma and x-ray absorption and dosage is of the highest importance, since it gives the prospect of a scientifically accurate method for determining dosage which applies ot both gamma and x-rays.

REVIEWS AND ABSTRACTS

Acta Radiologica. A New Journal Devoted to Radiology.

The first issue of Acta Radiologica appeared July 25, 1921, this journal being published by the Radiological Societies of Denmark, Finland, Norway and Sweden, with Professor G. Forssell of Stockholm, Sweden, as Editor. We quote the following from the editorial in the first issue:

"This journal which is now making its appearance before the world of science is the fruit of the collaboration between the associations of medical radiology in Denmark, Finland, Norway and Sweden. United as they are by a common culture and similar medical training, the radiologists of Scandinavia and Finland have decided to present the results of radiological research in their respective countries through the medium of their own journal."

"Medical roentgenology as well as radiotherapy and heliotherapy stand on a high level in these countries which have associated themselves with Acta Radialogica, and scientific reseorch in these subjects is here in a promising state of development."

"We possess well-equipped roentgenological departments at all our university clinics and at the big municipal hospitals, and these departments have their own chiefs who devote themselves entirely to radiology. New independent roentgenological departments are springing up year after year, and these are under the guidance of specialists. All hospitals have their own roentgenological laboratories."

"Denmark is known all over the world as the cradle of heliotherapy and as being that country in which this science has attained the highest pitch of development through Finsen's work and that of his followers. Sweden possesses a special hospital for the radiological treatment of cancer, in the shape of the Radium Home in Stockholm, and Lund University has also a special clinic for radiological therapy. The University Hospital "Rikshospitalet" in Norway has likewise a clinic for radiotherapy and heliotherapy, and a special hospital for the radiological treatment of cancer disease is being planned. In Copenhagen also a fully modern clinic for radiotherapy is under organization, equipped by means of funds which have been supplied by public contribution and national grants. There is systematic instruction in medical radiology at most of our medical colleges."

"But hitherto, however, an independent and special medium for the publication of our articles within the branch of medical radiology has been lacking. Our contributions have either been scattered in the special periodicals of other countries or else published in our home medical journals in which, in the majority of cases, they have been inaccessible to researchers from the foremost civilized countries on account of the difficulties encountered with regard to the comprehension of the Scandinavian languages."

"Ray-therapy is still in its infancy, but this branch of the art of healing has, by exact methods of research, entered the field of science and it has already attained very auspicious results in several forms of disease. It employs physical forces which deeply interfere with the normal and pathological functions of the organism, and it therefore demands not only a sufficient knowledge of radiophysics, but also scien-

tific apprenticeship in physiology and pathology, and a thorough knowledge of the research methods of internal medicine in those branches which come into touch with radiotherapy. In order to further develop his science, the radiotherapeutist must possess clinical training and have the opportunity of developing his science in his own clinic. At the same time, radiophysics is developing to a comprehensive science which it is impossible for a physician to master in a proper, scientific manner. Physicists have, therefore, been called ever more and more into the service of medical radiology and in all leading civilized countries there exist at certain radiological clinics scientific physical institutes."

"Whilst ray-therapy as well as x-ray diagnostics are increasingly developing towards specialization, yet, on the other hand, these special branches of medicine daily attain ever greater importance as auxillary sciences to most of the other branches of medical science. A large hospital already needs access to x-ray diagnostics as well as to radio therapy for most of its departments, and hospital doctors must have a corresponding opportunity of receiving an adequate training in these subjects and the possibility of following their development, in order to be enabled to rightly judge of the possibilities and limitations of the new science."

"Radiotherapy, however, will scarcely become the general practitioner's property within a reasonably near future. But with the simplification which the technique of x-ray diagnostics has gradually arrived at, above all through the triumphal progress through the world of the Coolidge tube, the time should not be far distant when an x-ray equipment for less complicated examinations should be part and parcel of the equipment of a vast majority of medical practitioners. Before long the cost of providing a simple x-ray instrumentarium will not much exceed the cost of a first-class microscope and as far as practical importance for a doctor's diagnostical proficiency goes, be comparable with a microscope. It will then, of course become necessary for those doctors who make use of the x-ray apparatus in their practice to carefully follow the development of x-ray diagnostics."

"Acta Radiologica will be published in volumes of about 500 pages, divided into four occasional numbers. Short articles are accepted for the journal itself, as a rule not exceeding 32 printed pages. More comprehensive contributions will be published as supplementary volumes to Acta and will be issued as detached works."

"We have decided to publish the articles in Acta in the English, French or German languages, according to the choice of the author. We shall thereby reach not only the Scandinavian doctors who, as a rule, can read these languages quite freely, but also have the opportunity of introducing our work to the whole of the medical world."

The first number contains ten articles, two of interest to the radium therapist. Lars Edling contributes a paper (in English) on Plastic Means of Application and their Use in Radium Therapy and R. M. Sievert a very interesting paper (in German) on the Distribution of the Primary Gamma Rays About Radium Applicators as Used in Therapy.

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The Dangers of Radiation and Radiology in Cancer . British Medical Journal, p. 290, Aug. 20 ,1921, and p. 331, Aug. 27, 1921. In the first mentioned issue of the British Medical Journal the leading editorial is devoted to the topic of the Dangers of Radiation.

"The two matters which have recently most occupied the minds of radiologists were both discussed in the section of radiology and electrotherapeutics at the annual meeting of the British Medical Association at Newcastle: the one is the method of x-ray therapy brought prominently to notice by the claims made by the Erlangen school; the other the hitherto not fully recognized dangers to radium and x-ray workers. Possibly the former has in some measure been responsible for the full realization of the latter."

"For a few years past a certain school of raliographers has been calling for more powerful apparatus, for the production of the highly penetrating type of x-rays in larger quantities, and for the use of massive doses in the treatment of various diseases; the culminating point of all this is for the present the German technique. A machine capable of yielding 200,000 volts and a tube which will pass for hours a current backing up a 16-in. spark gap at 2 to 2.5 milliamperes are asked for. Drs. Seitz and Wintz claim that they have worked out with such an apparatus the definite dose of x-rays which should be administered at a single sitting in cases of malignant disease, and which so administere d will "kill" the malignant cell. This contention, if true—and at the present time this "if" is all-important—would mark a very long step forward in scientific treatment from the hitherto more or less happy-go-lucky dosage which has been administered in an empirical manner. Whether these German workers will or will not eventually be proved to have established their points as to the definite dose and the single sitting, they at any rate have pursued their investigations upon thoroughly sound and scientific principles."

"At the recent meeting at Newcastle Dr. Knox, the President of the Section, in discussing the intensive treatment of cancer, spoke of the need for the careful study of the effect on the blood, not only as regards variation in the proportion of the different corpuscles, but also as to any effects on the corpuscles themselves and on the serum; the decision of questions as to the protection of workers is, as he pointed out, intimately associated with what is already known about these blood changes."

Mention is made of the work of Russ, Mottram, Lazarus-Barlow and Gulland on the action of the rays on the blood.

"In relation to the modern trend in favor of intensive x-ray treatment it is to be noted that it was asserted during the discussion that the dosage must be massive, as powerful indeed as the superficial tissues will stand, that it must be given at long intervals, and that frequent and small doses only stimulate the abnormal condition. These statements are open to question. In the past it has frequently been noticed that the blood count quickly improves and even becomes normal under small and frequently repeated fractional doses, with very small currents passing through the tube. This method avoids all the unpleasant effects so often produced upon patients by massive doses, and is not lightly to be set aside. The statement that these small doses stimulate the lesion has not been proved; we know, indeed, of no evidence in its favor."

The necessity for adequate protective measures for those who work with radium and x-rays is emphasized.

"As the effects of the high penetrating x-rays and the gamma rays of radium are identical, it follows that protection for radium workers is equally important, and generally speaking the principles upon which it is to be carried out will be the same, modifications being made to suit the special requirements of radium."

"There are many other practical details which still require consideration in order that workers may be thoroughly protected; among these are the suitability of rooms as regards size, ventilation, and the access of fresh air, the hours of work, sufficient holidays, and so on; but granted all the dangers and all the difficulties, there appears to be no reason why x-ray work at any rate, should not with care be made perfectly safe for both operators and patients."

In the August 27th issue of the British Medical Journal the following editorial comment is made on the subject of "Radiology in Cancer:"

"In view of the publicity that has been given to radiotherapy in the treatment of cancer by the publication of laudatory articles in the medical and lay press, and the extraordinary claims that have been put forward by the authorities of the West London Hospital, the British Association for the Advancement of Radiology and Physiotherapy, which includes the majority of radiologists in the country, has deemed it advisable to issue to the lay press a considered statement on the use of these agents. The claim put forward by the Erlangen school is that it is possible by a special method to administer a dose of x-rays which will cure cancer in one application. The statement points out that the treatment, which has not yet been thoroughly tested, possesses great potential dangers, and may not prove as efficacious as the claims now made would suggest. In the nature of the rase, however, no certainty can be arrived at for some years. The unwarranted laudation of this change in technique will, it is thought, probably lead to a reaction, and bring discredit upon x-ray treatment in general. The subject has so recently been discussed by Dr. Knox in his address to the Section of Radiology at the annhal meeting of the British Medical Association, and in a leading article published last week (pp. 267 and 290) that we need not reproduce the statement in full. It will suffice to say that the experts by whom it is issued state that the time has not yet come when radiotherapy may be regarded as the first choice in the treatment of the majority of cases of cancer; they believe that, of any single method, surgery still offers the best prospect of cure in nearly all cases of cancer, and that until much more convincing proof of the efficacy of x-rays or other form of radiation is forthcoming the possibility of successful surgical intervention ought to be, in each particular case, fully discussed. They go on, however, to express the opinion that a closer co-operation between the surgeon and the radiologist would lead to a clearer appreciation of the value of radiation in treatment, and that in all cases both surgery and radiation therapy should be fully considered, with a view to making the fullest use of both. Combined treatment ,it is thought, offers the greatest hope of success. Radiologists in this country, the statement continues, have, during the past few years, so far perfected their technique that the risk of any injury to the patient is now small. provided that the treatment is under the direction of a medical man of

wide experience in this class of work. If the prospects held out by the more drastic procedure prove to be better than those offered by existing methods full advantage will be taken of it in this country; the real contributions to progress of the Erlangen school are held to be that it has employed in suitable quantities x-rays of a higher penetration than that hitherto used, and has carefully systematized already known methods of measuring dosage. It is unnecessary to import the apparatus from Germany; several firms in this country are now making the requisite equipment, so that difficulty of obtaining plant will not be a bar to research. The statement concludes by pointing out that x-rays have already relieved suffering and prolonged active life in thousands of cases, and have even effected a few apparent cures, while their value in helping to prevent return after operation is now generally recognized. It would therefore be neither more nor less than a calamity if public disappointment resulting from unfulfilled promises were to bring discredit on radiation therapy, which is in reality a powerful agent in the warfare against disease."

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Frederick Soddy. The Interpretation of Radium and the Structure of the Atom.

In 1920 there was issued the fourth edition* of Prof. Soddy's book on the Interpretation of Radium and the Structure of the Atom.

For some years the third edition printed in 1912 has been exhausted, and the welcome new edition, revised to date, maintains its place as the most interesting non-mathematical presentation of the subject. In the preface of the original 1908 edition Prof. Soddy says:

"The book contains the main substance of six popular experimental lectures delivered in the University of Glasgow at the beginning of the year, but being relieved from the necessity, always present in lecturing, of co-ordinating the experimental and descriptive sides, I have, while adhering to the lectuse form of address, entirely rearranged and very largely rewritten the subject matter in order to secure the greatest possible degree of continuity of treatment.

In the preface to the fourth edition the author adds:

"In again revising this book I have conformed to the earlier plan of writing what I should have said if the lectures had been delivered in 1920 instead of 1908. The original statement has been amplified rather than modified. It has lost, long since, the appearance of challenge to existing theories which at first it may have presented.

The book is illustrated with forty-four photographic reproductions and diagrams and contains sixteen chapters under the following topics:

The Discovery of Radioactivity; Radium; The Rays of Radioactive Substances (2 chapters)); The Radium Emanation; Helium and Radium; Theory of Atomic Disintegration; The Origin of Radium; The Successive Changes of Radium; Radioactivity and the Nature of Matter; Radioactivity and the Evolution of the World; The Thorium and Actinium Disintegration Series: The Ultimate Structure of Matter; The Nuclear Atom; Isotopes; The X-rays and Concluding Evidence.

This is a book which every radium therapist should own and read.

*G. P. Putnam's Sons, New York, $3.75.

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